ORIGINAL ARTICLE

Comparative Randomized Study of Balanced Salt Solution and Ringer Lactate Fluid Administration on Plasma Electrolytes, Acid Base Status and Renal Function in Cardiac Surgeries

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ABSTRACT

Background: Intraoperative fluid therapy is an integral part of anaesthesia management[1]. Proper fluid therapy intra operatively will avoid hypovolemia and hypotension also maintains proper tissue perfusion and oxygen Patient who have to undergo cardiac surgery present a major challenge to the anaesthetist. No solution is ideal for fluid therapy in cardiac surgery.

This study was carried out with the aim to compare and assess Balance salt solution and Ringer Lactate (RL) fluid administrations on plasma electrolytes, acid base status and renal function in patient undergoing cardiac surgeries on cardiopulmonary bypass.

Method: All patients were managed by standard institutional protocol and were randomly distributed in two groups according to fluid administered intravenously and priming solution used in cardiopulmonary bypass circuit. Total Cases [Group A (n=40) + Group B (n=40) = 80]

Group A (n=40): received balanced salt solution intravenous (5ml/ kg /hour) and in the priming solution 1500 ml + 6% hydroxy ethyl starch 500ml (130/0.42)

Group B (n=40): received RL intravenous (5ml/ kg /hour) and in the priming solution1500 ml + 6% hydroxy ethyl starch 500ml (130/0.42). Primary variables recorded are plasma electrolytes (sodium, chloride), lactate, bicarbonate, pH levels. Secondary variables blood glucose, serum creatinine levels, hemodynamic parameters (HR, MAP, CVP, Spo2) were noted at the interval mentioned Base line (T0), after anaesthesia induction (T1), before going on bypass (T2), after coming of bypass (T3), at the end of surgery (T4) : 2 hr after surgery (T5) and 24 Hr after beginning of surgery (T6). Continuous data were summarized in from of mean and standard deviation. The difference in means was analyzed using student t- test. Count data were summarized in form of proportions. The difference in proportions was analyzed using Chi-Square test. The level of significance was kept 95% for all statistical analysis

Results: There were no statistically significant differences in the demographic data between the two groups. In both the groups all variables were comparable at baseline. There is hyperchloremia in group B than group A at interval T5 and T6. The mean HCO_3^- was significantly higher in group A than group B at interval T3,T5,T6. The mean Lactate lavels were significantly higher in group B than group A at all the time intervals. The difference in mean blood glucose lavels was found to be statistically significantly high at T2, T4, T5, T6 time intervals.

No complications with balanced salt solution and ringer lactate were encountered.

Conclusion: The balanced salt solution is better fluid than ringer lactate solution due to reduced incidence of hypercloramic metabolic acidosis and less increased level of serum glucose and lactate. Renal functions are better preserved in Balance salt solution.

Key Words: Balanced salt solution, Ringer lactate, Cardiopulmonary bypass.

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INTRODUCTION

Intra operative fluid therapy is an integral part of anaesthesia management[1]. Proper fluid therapy during surgery will avoid hypovolumia, hypotension and maintains proper tissue perfusion and oxygenation. Hypotension can be avoided by proper diagnosis and treatment of the underlying cause. Important causes of hypotension are blood loss, fluid depletion, third space losses, evaporative losses from wound, hypoxia and vasodilatory effect of anaesthetic agent. Fluid therapy should not only lead to stabilization of macro circulation, but also of microcirculation. Microcirculation especially seems to be affected by different volume substitution fluid. Physiology and pathophysiology of fluid compartment should be accounted for when decision has to be made among different solution[2]. Patient who have to undergo cardiac surgery present a major challenge to the anaesthetist beyond the problem of fluid therapy. In cardiac patient oedema is due to water and salt retention so total body water and sodium is more in these patient but retention of water is more than that of salt so hyponatremia is frequently seen which is dilutional. Remember that hyponatremia is usually dilutional and need fluid restriction. In cardiac patient when diuretics instituted urine output will increase and will not follow routine guidelines of fluid replacement. So our aim is to remove extra fluid from the body by restricting fluid intake despite good urine output. During cardiac surgery the patients may experience extreme condition like cardiac arrest or deep hypothermia unlike any other sub speciality. In the immediate postoperative period, relative insufficiency of blood volume often occurs, especially use of cardiopulmonary bypass often induces capillary leakage which may lead to interstitial oedema during concomitant intravasal volume depletion[3]. Maximising the cardiac output by fluid infusion benefits patient undergoing cardiac surgery but they may not tolerate large volume of fluid due to impaired cardiac performance hence fluid resuscitation without or with minimal risk of fluid excess might be beneficial. A perfect balanced fluid could be considered to be one in which any change induces in total concentration of non volatile weak acid is offsets by a change in strong ion difference so that pH remain stable[4]. No fluid is perfect fluid for perioperative volume replacement in the extracellular space during cardiac surgery.

Currently available balanced crystalloid solution have lower overall osmolarity than 0.9 % NaCl with a lower Sodium (Na) concentration and much lower lower chloride ion (Cl) concentration. Reduction in anionic content is compensated for by the addition of stable organic anion buffer such as lactate, gluconate or acetate. Colloid intravascular fluid therapy affects acid base balance and can cause iatrogenic acidosis. Which is the result of administration chloride rich fluid and administration of sodium bicarbonate to correct acidosis.

This study was carried out with the aim to compare and assess Balance salt solution (BBS) and Ringer Lactate (RL) fluid administrations on plasma electrolytes, acid base status and renal functions in patient undergoing cardiac surgeries on cardiopulmonary bypass (CPB).

MATERIALS AND METHODOLOGY

It is a Hospital based, prospective randomized double blind, Interventional study. Total 80 Cases, 40 in each group were studied. Randomization was done by sealed envelope method & blinding was done by covering the solution bottle with paper bag.

Group A (n=40) received balanced salt solution (BSS) intravenous (5ml/ kg /hour) and in the priming solution1500 ml + 6% hydroxyethyl starch 500ml (130/0.42)

Group B (n=40) received RL intravenous (5ml/ kg /hour) and in the priming solution1500 ml + 6% hydroxyethyl starch 500ml (130/0.42).

Patients of either sex undergoing cardiac surgery, ASA Grade II, III, age 30-60 Years, weighting 40-60 kg with normal coagulation profile liver and kidney functions were included. Thorough pre anaesthetics check up and written informed consent was obtained.

Patients with congestive heart failure, renal, liver and respiratory disorder, emergency and redo surgery were excluded from the study.

After confirming written informed consent and fasting status, patients were taken in the operation theatre. 18G intravenous cannula was secured and study fluid was started @ 5ml/kg/hr in peripheral line according to the assigned group. 12 lead ECG and pulse oximeter were attached. Patients were premedicated with injection morphine 0.1 mg/kg intramuscular (IM) and injection promethazine 0.5 mg/kg (IM). Femoral artery cannulation was performed and central venous catheter

was inserted into right internal juglar vein under local anaesthesia. Base line parameter were recorded in the form of Heart Rate (HR), Systolic blood pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), Central venous pressure (CVP) and Arterial Blood Gas(ABG). Patients were preoxygenated with 100% Oxygen for 3 min. Induction of anaesthesia was done with inj midazolam 0.05 mg/kg, inj. fentanyl 5µg/kg & Inj. Etomidate 0.3mg/kg IV slowly over a period of 60-90 second until there was loss of eyelash reflex. Inj. Rocuronium bromide 0.9 mg/kg I.V. was given to facilitate the intubation. Oral tracheal intubation was attempted by appropriate sized cuffed endotracheal tube at 2 min after induction. Position of tube was checked and secured with adhesive. HR, MAP, CVP were recorded. Anaesthesia was with 100% O2, inj. midazolam 0.01mg/kg hourly, inj. Vecuronium 0.05 mg/kg every half hourly. Nasopharyngeal temperature probe and nasogastric tube were secured. Patients were catheterised with Foleys urinary catheter and urine output was measured. Patient taken on cardio pulmonary bypass circuit which was primed with 1500 ml balanced salt solution+ 500ml 6% Hydroxy ethyl in Group-A, 1500ml RL + 500ml 6% Hydroxy ethyl starch (130/0.42) in group B.

After completion of surgery patients were shifted to ICU. Extubation criteria include adequate level of consciousness, muscle strength, stable cardiovascular status, normothermia, adequate pulmonary function and minimal thoracotomy tube drain.

Primary variables plasma electrolytes Sodium, chloride, lactate, bicarbonate and pH level. Secondary variables blood glucose, serum creatinine levels, hemodynamic parameters (HR,MAP) were noted at the interval mentioned Base line(T0), After anaesthesia induction(T1), Before going on bypass (T2), After coming off bypass(T3), At the end of surgery (T4), 2 hour after surgery (T5) and 24 Hours after beginning of surgery(T6).

Data were summarized in from of mean and standard deviation. The difference in means was analyzed using student t- test. Count data we form of proportions. The difference in proportions was analyzed using Chi-Square test. The level of significance was kept 95% for all statistical analysis re summarized in form of proportions. The difference in proportions was analyzed using Chi-Square test. The level of significance was kept 95% for all statistical analysis.

RESULTS

There were no statistically significant difference in the demographic data between the two groups .In both the groups all variables were comparable at baseline. (Table 1, 2).

Table 1: Showing Demographic data and other variables

	Group A		Group B		P Value	Significance
Mean Age (years)	Mean	SD	Mean	SD		
	39.80	8.13	39.65	8.09	0.934	N.S.
Mean Weight (kg)	48.80	7.29	49.26	7.33	0.783	N.S.
Mean Height (cm)	147.70	8.04	148.35	8.27	0.722	N.S.
Duration of Surgery (Hours)	2.70	0.56	2.48	0.51	0.064	N.S.

Table 2: Showing Demographic data and other variables

	Group A		Group B	
	No.	%	No.	%
ASA Grade 2	25	62.5	23	57.5
ASA Grade 3	15	37.5	17	42.5
Total	40	100.00	40	100.00
	No.	%	No.	%
Male	19	47.5	15	37.5
Female	21	52.5	25	62.52

Baseline variables were comparable in both the groups at different time intervals.

It was observed that there was no significant difference in mean heart rate, among both the groups at different time intervals.

There was no statistical significant difference between both the groups in mean of SBP and DBP. MAP at the interval of T0, T1, T2, T3, T5, T6 (p value >0.05). There was statistical significant difference between both groups in mean of MAP at interval T4. The mean of MAP was higher in group B than group A.

There was increased in MAP after anesthesia induction and decreased at T2 interval.

There was statistically significant differencebetween both the groups at all intervals in the mean of lactate concentration which was higher in group B than group. In our study there was no significant difference between two groups at baseline (p value >0.05) (Ggraph 1)

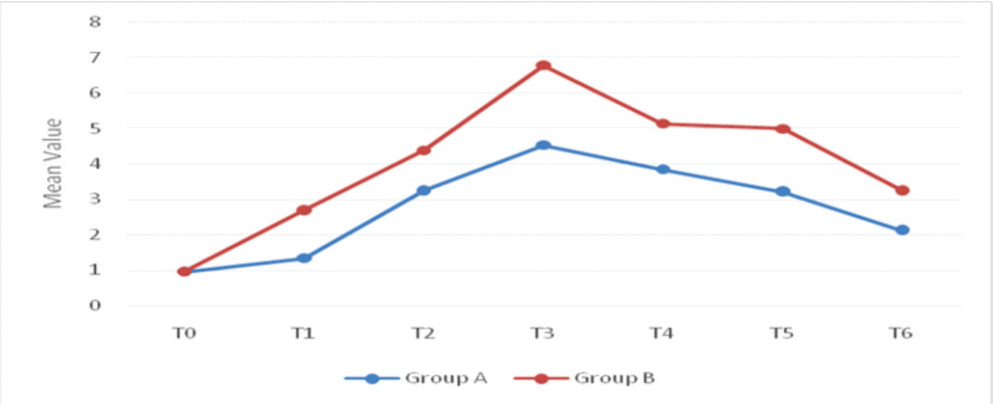
Table 3: Showing mean heart rate and mean MAP in both the groups

	Mean Heart Rate					Mean Arterial Pressure				
	Group A		Group B		P Value	Group A		Group B		P Value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
T0	82.73	12.42	82.05	16.46	0.836	83.12	13.63	78.93	14.50	0.185
T1	110.23	21.07	119.58	22.22	0.057	103.77	16.06	107.28	19.61	0.385
T2	85.08	12.16	84.00	12.82	0.701	80.42	14.23	83.35	16.47	0.398
T3	95.65	11.56	98.35	13.83	0.346	81.57	14.79	85.75	15.74	0.225
T4	77.60	10.34	73.75	15.46	0.194	74.75	10.60	82.03	18.73	0.035
T5	80.98	10.99	84.13	11.37	0.211	79.82	10.15	81.43	11.94	0.520
T6	81.55	13.04	81.83	16.74	0.934	85.00	9.88	80.48	12.19	0.075

Table 4: Showing mean Na^+ and HCO_3^- distribution in the two groups.

	Na^+					HCO_3^-				
	Group A		Group B		P Value	Group A		Group B		P Value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
T0	138.05	2.89	136.83	2.84	0.059	22.47	1.10	22.82	1.62	0.26
T1	138.00	2.83	138.35	3.32	0.613	22.03	0.99	22.15	0.96	0.60
T2	137.95	3.00	138.90	3.69	0.209	21.49	0.98	21.48	0.95	0.99
T3	137.6	3.23	137.98	2.59	0.568	20.21	1.30	19.49	1.48	0.022
T4	138.00	3.31	137.98	3.63	0.974	20.77	1.56	20.54	1.56	0.502
T5	137.35	3.12	136.88	2.82	0.477	21.60	1.23	20.97	1.46	0.037
T6	137.53	2.82	137.95	2.63	0.487	22.26	1.10	21.06	1.50	0.0001

The baseline blood glucose levels were comparable in both of the groups. In present study the mean glucose was higher in group B than group A. This can be explained due to conversion of lactate to bicarbonate and gluconeogenesis. Various studies were in accordance with present study. There was no significant difference

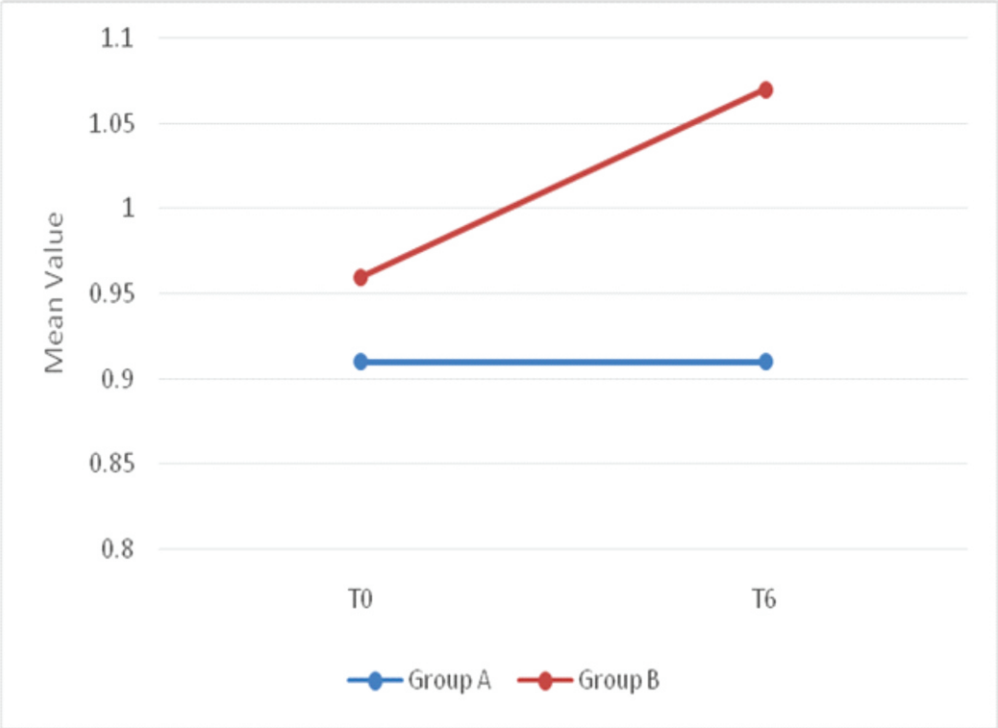


Graph 1: Showing distribution of mean Lactate levels in two groups.

Graph 2: Showing blood Glucose lavels in both groups

between both the groups at baseline and interval T1 and T3. There was significant difference between group A and group B at interval T2, T4, T5, T6. The mean glucose was higher in group B than group A. (Graph 2) There was significant difference between group A and group B in Serum creatinine and p value was 0.0003 the mean creatinine was higher in group B than group A while base line values were comparable.

There was no significant difference in Sodium (Na+) between two groups (p value>0.05) at baseline and at all intervals.

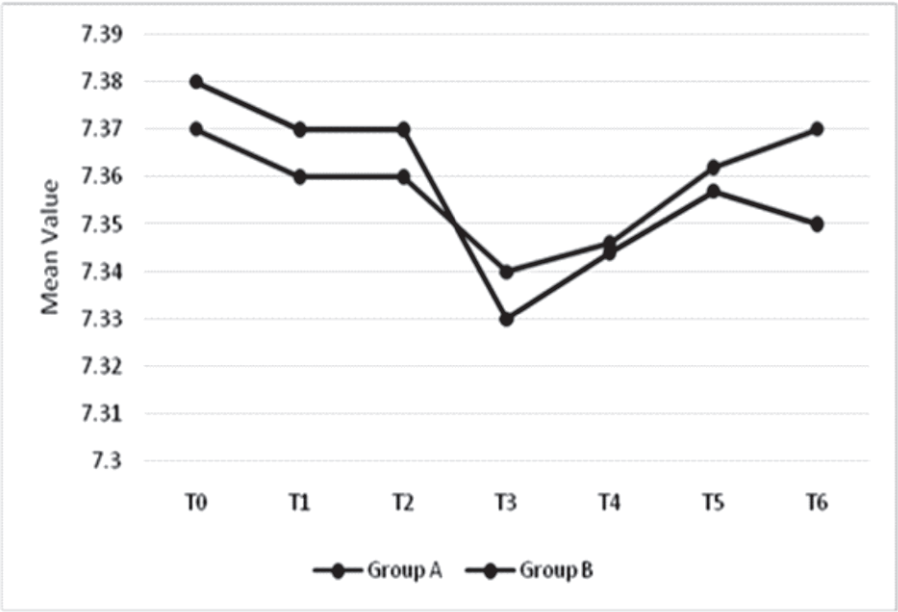


Graph 3: Showing mean Creatinine levels in both the groups

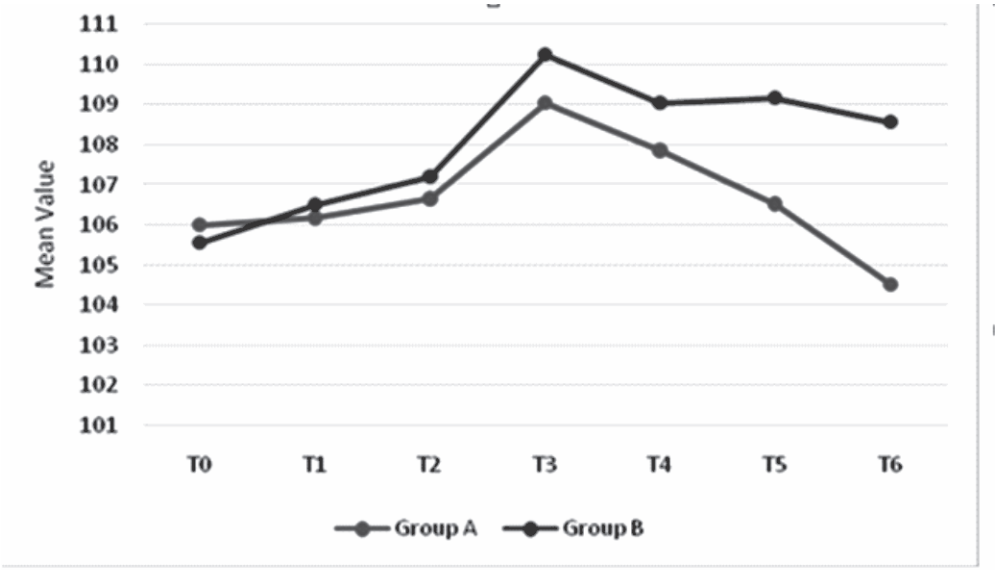
In our study, there was statistically significant difference between both groups in mean **Bicarbonate (HCO_3^-)** at interval T3,T5,T6. Mean **HCO_3^-** was higher in group A than group B.

We found that the Cl^- was lower in group A than group B at interval T5, T6 this is in accordance with previous studies.

In our study, in the reference of **pH** there was no significant difference between both the groups (p value >0.05) at baseline and interval at T1,T2,T3,T4,T5. (Graph 4). There was significant difference between both the groups at interval T6. The mean pH was higher in group A than group B.



Graph 4: showing pH distributions in two groups.



Graph 5: Showing mean chloride distribution in two groups

The above Graph shows the mean Cl^- distribution in both the groups. There was no statistical significant difference in mean of Cl^- at the interval T0,T1,T2,T3,T4 between both the groups.

There was statistical significant difference between both the groups at interval T5,T6.

The Mean of Cl^- was higher in group B than group A.

DISCUSSION

Perioperative intravenous fluid therapy has been a much neglected area of clinical practice[5,6] and suboptimal prescribing has often resulted in morbidity and even mortality[7]. During CPB, mild to severe dysfunction occurs in many organs due to physiological alterations inherent to this technique. As blood is exposed to foreign surfaces, a series of inflammatory reactions that induce changes in capillary permeability are activated. Furthermore, the hemodilution causes by CPB lowers the osmotic pressure, resulting in oedema that may compromise the normal function of many organs[8,9].

A balanced electrolyte solution has the physiological electrolyte pattern of plasma in terms of sodium, potassium, calcium, magnesium, chloride and their relative contributions toward osmolality and achieves a physiological acid-base balance with bicarbonate or metabolizable anions. Infusion of such a balanced solution is devoid of the risk of iatrogenic disruptions except for potential volume overload. A balanced solution should reflect the physiological roles of the sodium, potassium, calcium, and magnesium cations, and also contain chloride and phosphate anions, and, above all, bicarbonate[10].

With this back ground,the present study was performed to compare Balanced Salt Solution and Ringer Lactate fluid administration on plasma electrolytes, acid base status and renal function in cardiac surgery on CPB.

Various studies have been performed to see the effect of balanced salt solution and RL solution on heart rate during at different time intervals. In our study we found that difference in heart rate was not significant among both groups during all time intervals this is in accordance with previous studies conducted by Thomas Stand et al in 2010 who found no significant difference among Hydroxyethyl starch 6% in a balanced electrolyte solution during cardiac surgery[11].

kumar AK, et al in 2017 found that the difference in heart rate was not significant by administration RL and Kabilyte. In our study (Table 3) there was no significant difference between both the groups (p value >0.05). Increased in heart rate after anesthesia induction (T1) in both the groups might be explained as the effect of laryngoscopy and intubation[12].

The presenting study was similar with Anne Kiran Kumar et al in 2017 and Jigar Patel et al in 2016 where they also observed that the MAP was not significantly differ after administration of RL and Kabilytev[12] and priming the bypass machine pump by albumin, Hydroxyethyl starch respectively[13].

In our study (Table 3) there was no significant difference in MAP between both the groups at interval T1,T2,T3,T5,T6 (p value >0.05) except at T4. The mean of MAP was higher in group B than group A.

Boom CE, et al in 2013 and Volta CA, et al in 2013 also observed same results after administration of sodium lactate and balanced fluid during cardiac surgery[14, 15].

In reference to S_PO_2% the presenting study was comparable with Volta CA, et al in 2013 and Hasan AL per Gurbuz et al in 2013 they also found that the S_pO_2% not significantly differ among both the study groups.

There was no significant difference in Sodium (Na^+) between both the groups (p value>.05) at baseline and at all intervals. This was in concordance with study of Carlo Alberto et al in 2013[15].

Different studies have been performed to see the effect of balanced salt solution and ringer lactate on chloride (Cl^-). In our study we found that the Cl^- was lower in group A than group B at interval T5, T6 this is in accordance with previous studies .

James MFM et al in 2011 also found that the Cl^- was not increased by balanced salt solution administration but increased by RL infusion during surgery[16].

The present study was in concordance with Carlo Alverto volta et al in 2013 who found that there was no hyperchloremia with balanced salt solution in patients undergoing abdominal surgeries but normal saline administration should dilute the bicarbonate concentration of the extracellular space. Based on the Stewart's approach, the decrease of the strong ion difference is mainly the result of the plasmatic increase of chloride (hyperchloremic acidosis)[15].

The presenting study was similar with Bertrand Guidet et al in 2010 they found that dilutional-hyperchloraemic acidosis is a side effect, mainly observed after the administration of large volumes of isotonic saline as a crystalloid. In this particular setting, however, the effect remains moderate and relatively transient (24 to 48 hours), and is minimized with the use of balanced solution[17].

Our study results differ with Kumar AK, et al in 2017, observed higher levels of chloride (RL and sterofundin) compared to plasma, less than that in normal saline but there was no significant difference between the groups in reference to the chloride[12].

There was no significant difference between both the groups at baseline and at interval T1,T2,T4 in mean bicarbonate (HCO_3^-).

There was statistically significant difference between both groups in mean bicarbonate (HCO_3^-) at interval T3,T5,T6. Mean HCO_3^- was higher in group A than group B.

The present study was in concordance with Roger J Smith et al in 2010, who found that there was reduced incidence of metabolic acidosis with balanced salt solution group[4].

Volta CA, et al in 2013 found similar result as our study that bicarbonate level was higher with balanced salt solution than unbalanced salt solution[15].

Stand T, et al in 2010 observed in their study that The serum chloride level (mmol/L) was lower ($p < 0.05$ at the end of surgery), and arterial pH was higher in the balanced group at all time points except baseline, and base excess was less negative at all time points after baseline ($p< 0.01$)[11].

The presenting study was against the study by Kumar AK, et al in 2017 who found that balanced salt solution and ringer lactate give similar outcome on acid basis status (no change)[12].

In our study in the reference of pH there was no significant difference between both the groups (p value >0.05) at baseline and interval at T1,T2,T3,T4,T5. There was significant difference between both the groups at interval T6. The mean pH was higher in group A than group B.

The present study was in concordance with Volta CA, et al in 2013, they found that there was metabolic acidosis with unbalanced salt solution [15].

Guidet B, et al 2010 found that pH was more with balanced solution then unbalanced solution. And they concluded that dilutional hyperchloraemic acidosis is a side effect, mainly observed after the administration of large volumes of isotonic saline as a crystalloid. In this particular setting, however, the effect remains moderate and relatively transient (24 to 48 hours), and is minimized with the use of colloids[17].

Kumar AK, et al in 2017 found that pH was more with balanced solution than and unbalanced solution and also lactate and glucose level was more with RL solution[12].

The present study (graph 1) was in accordance with Volta CA, et al in 2013, and they found that the lactate level was more with RL Solution then balanced salt solution[15].

In our study there was no significant difference between two groups at baseline (p value >0.05). There was statistically significant difference between both the groups at intervals T1, T2, T3, T4, T5 and T6 the mean of lactate concentration was higher in group B than group A.

The baseline blood glucose was comparable in both of the groups. In present study the mean glucose was higher in group B than group A. This can be explained due to conversion of lactate to bicarbonate and gluconeogenesis.

Various studies were in accordance with present study.

Kumar AK, et al in 2017, found similar results that the glucose level was more with RL solution[7].

The present study (graph 2) was consistent with Carlo Alverto Volta et al in 2013, as they found that the glucose level was more with RL Solution than balanced salt solution group[15].

There was significant difference between group A and group B in Serum creatinine and p value was 0.0003 the mean creatinine was higher in group B than group A.

The present study was in concordance with SM Alvani, et al 2012 and they also found that kidney function was better in the short term in the HES group than in the other two groups (RL and Gelatin Group)[18].

Carlo Alverto Voltaet et al in 2013 also observed that the use of balanced solutions was responsible of less

alteration of kidney function and it might be associated with an early anti-inflammatory mechanisms triggering.

The present study was against with Hasan Alper Gurbuz et al in 2013. And they did not document any difference between HES and crystalloid solutions used for CPB priming regarding postoperative outcomes like postoperative bleeding, renal functions and the use of blood and FFP[6].

Limitations of the study This study had some limitations including the absence of the data expressing cardiac contractility after BSS or RL infusion and measurement of extra vascular lung water. We were unable to measure due to lack of suitable monitors.

CONCLUSION

The BSS (Kabilyte) is better fluid than RL solution due to reduced incidence of hyperchloremic metabolic acidosis and less increased level of serum glucose and lactate. Renal functions are better preserved in BSS group.

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